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Development and Validation of a Land Surface Phenology Product from VIIRS

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Outline

1. Algorithm of detecting land surface phenology from VIIRS
2. Comparison of VIIRS phenology with MODIS phenology
3. Validation of VIIRS phenology using PhenoCam and Landsat observations
4. Summary

Hybrid Piecewise Logistic Model for Simulating Temporal Vegetative Trajectory

$$VI(t) = \begin{cases} \dfrac{c}{1 + e^{a + bt}} + VI_b \\ \dfrac{c + dt}{1 + e^{a + bt}} + VI_b \end{cases}$$

Favorable growth condition

Vegetative stress condition

t is time in days

$VI_{(t)}$ is the VI value at time *t*

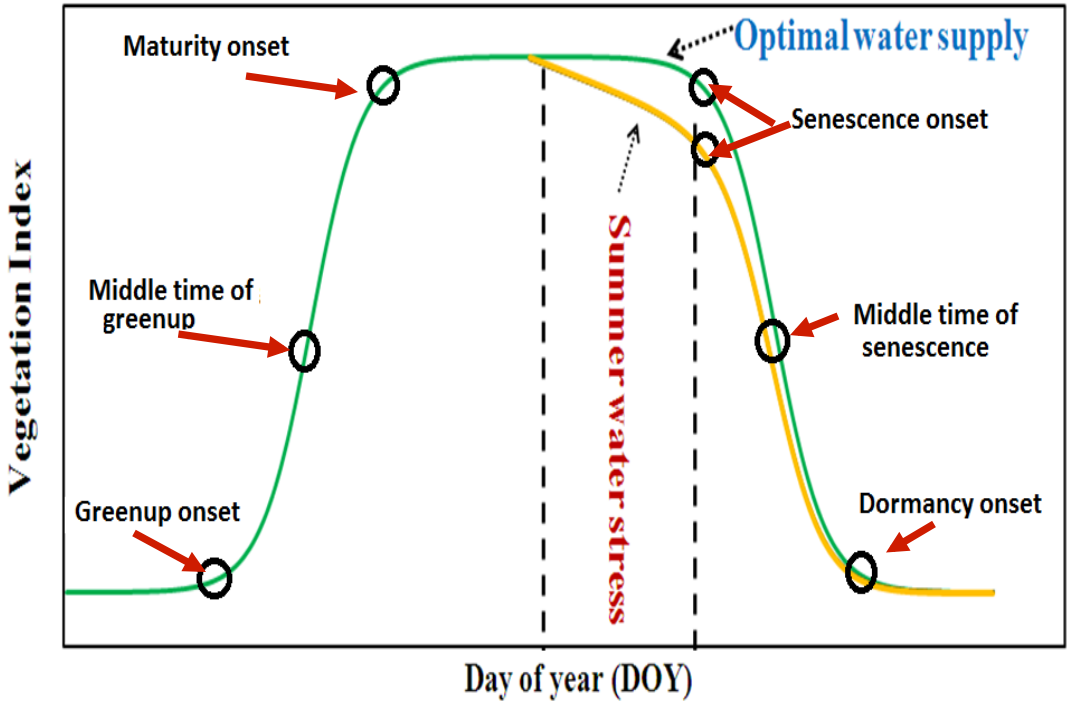
VI_v is the VI value in vegetation growth

a and ***b*** are vegetation growth parameters

d stress parameter

$c+VI_b$ is the maximum VI value

VI_b is the background VI value



Assessment of Good Quality Observations During Vegetation Growing Season

Proportion of good quality observations (PGQ) during a growing season:

$PGQ=N_{qao}/T$

T is the total number of VI during a growing season

N_{qao} is the moving-window of good qual observation within a growing season.

If there is one or more good VI values within a 9-day moving window, then it counts as one good observation.

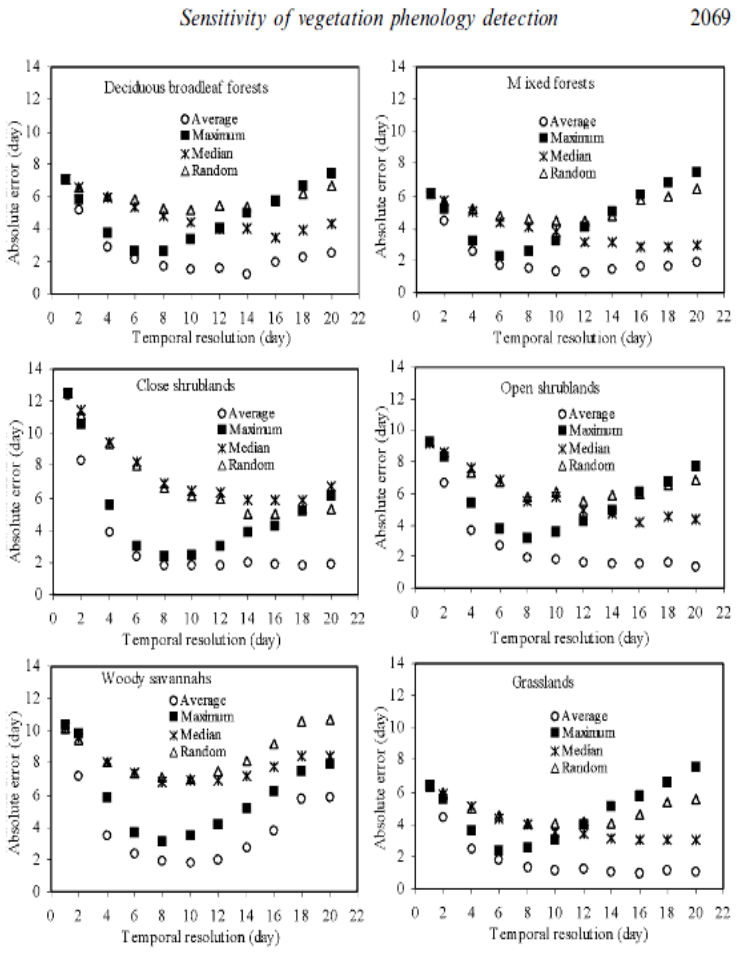


Figure 4. Average of absolute errors derived from four phenological transition dates using simulated daily data.

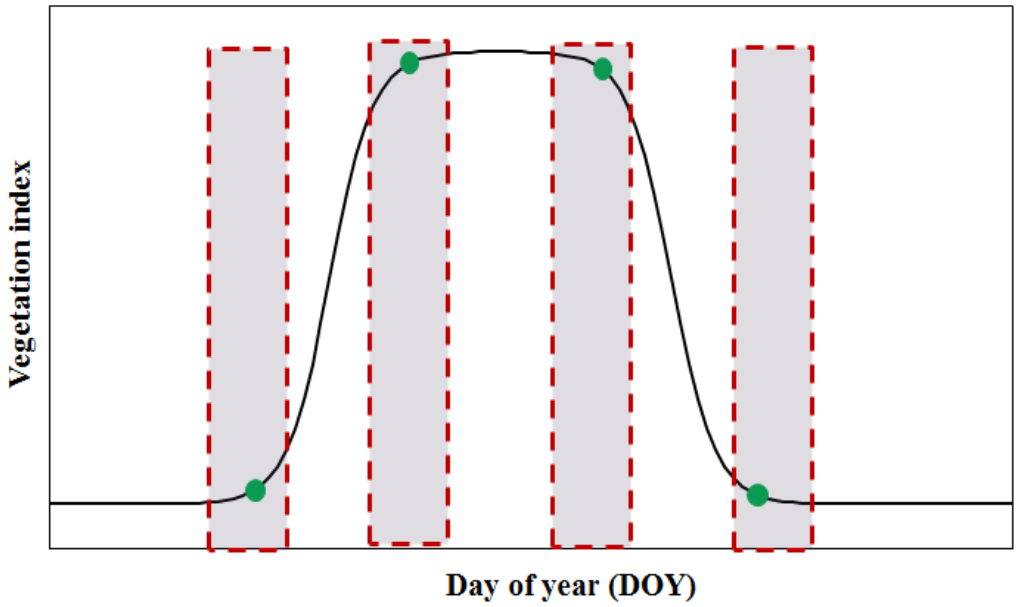
Zhang *et al.* 2009

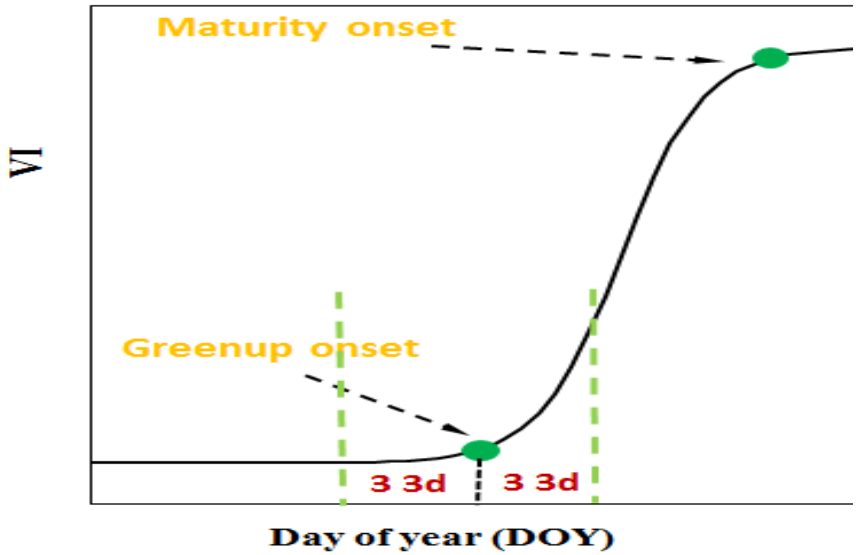
Qualifications of Good Observations Around Phenological Events

QA in the detection of greenup onset (QAgin):

QAgin=100*Ngin/6

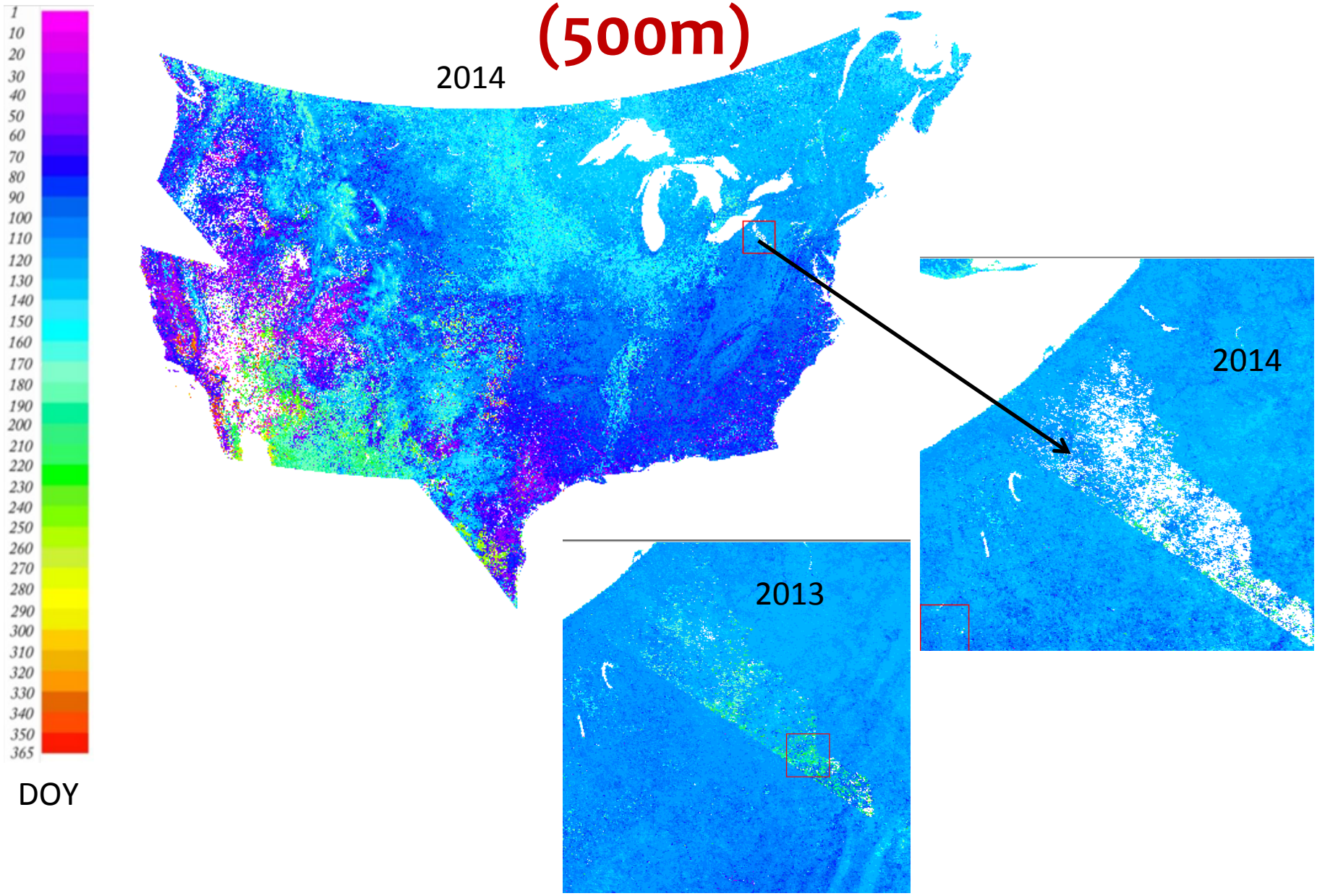
Ngin is the number of good quality obs during three 3-day periods before and after the detected timing of greenup onset





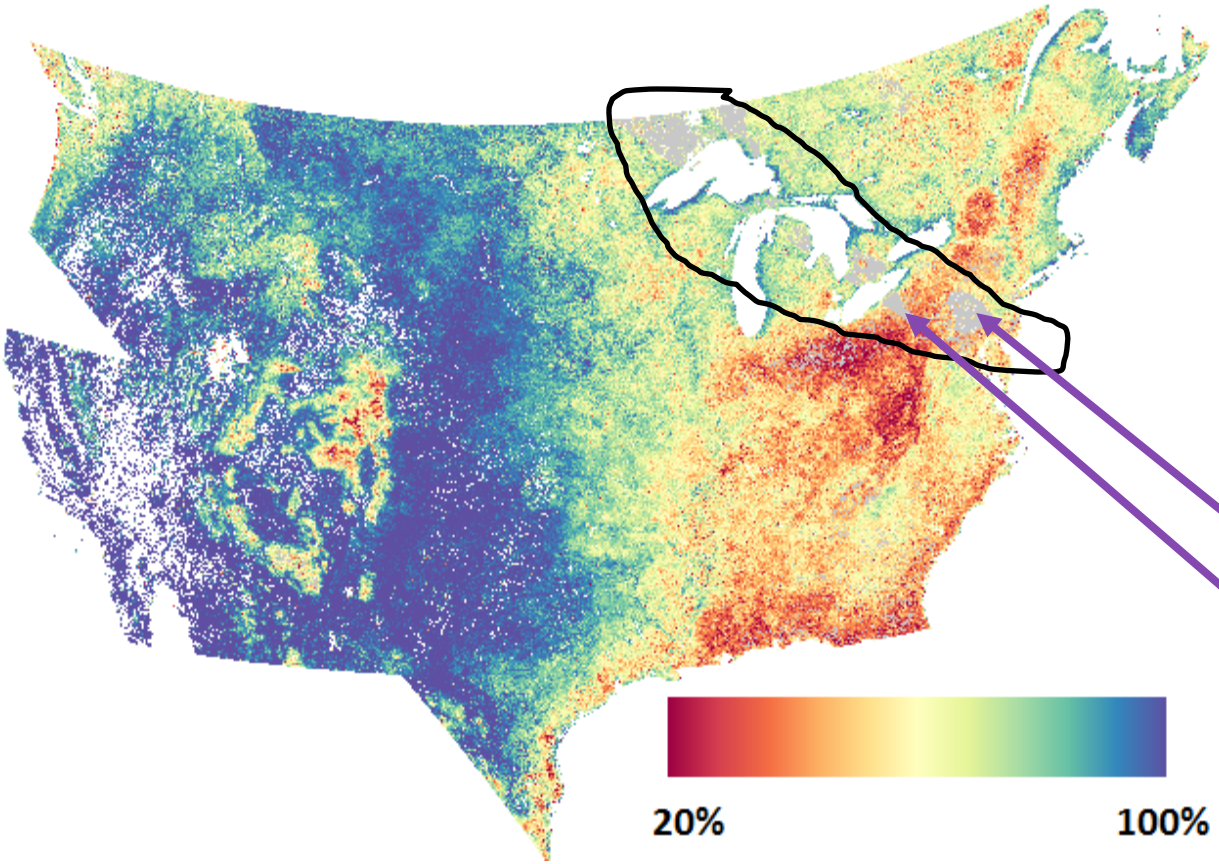
QA in maturity onset: QAgma=100*Ngma/6
QA in senescence onset: QAgde=100*Ngde/6
QA in dormancy onset: QAgmi=100*Ngmi/6

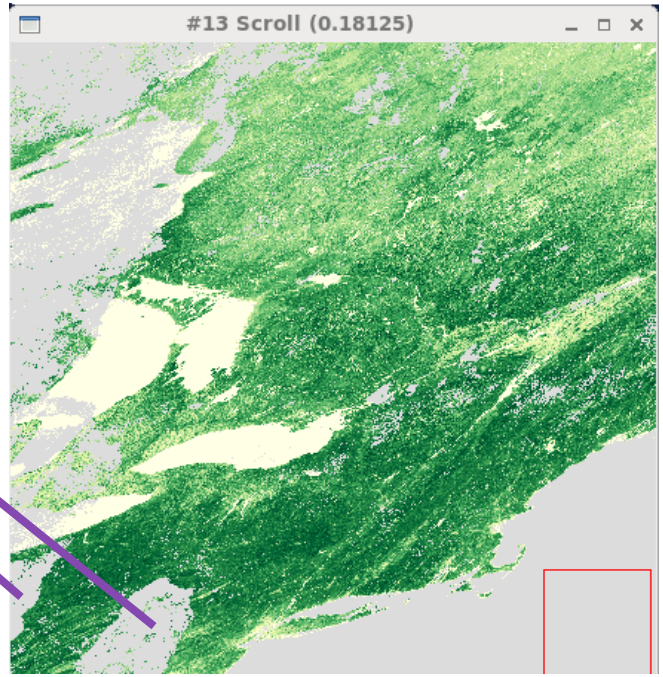
Phenology Detected from Daily VIIRS NBAR (500m)



Quality of Time Series of VIIRS Data

Proportion of Good Observations (PGQ) **During a Growing Season (2014)**

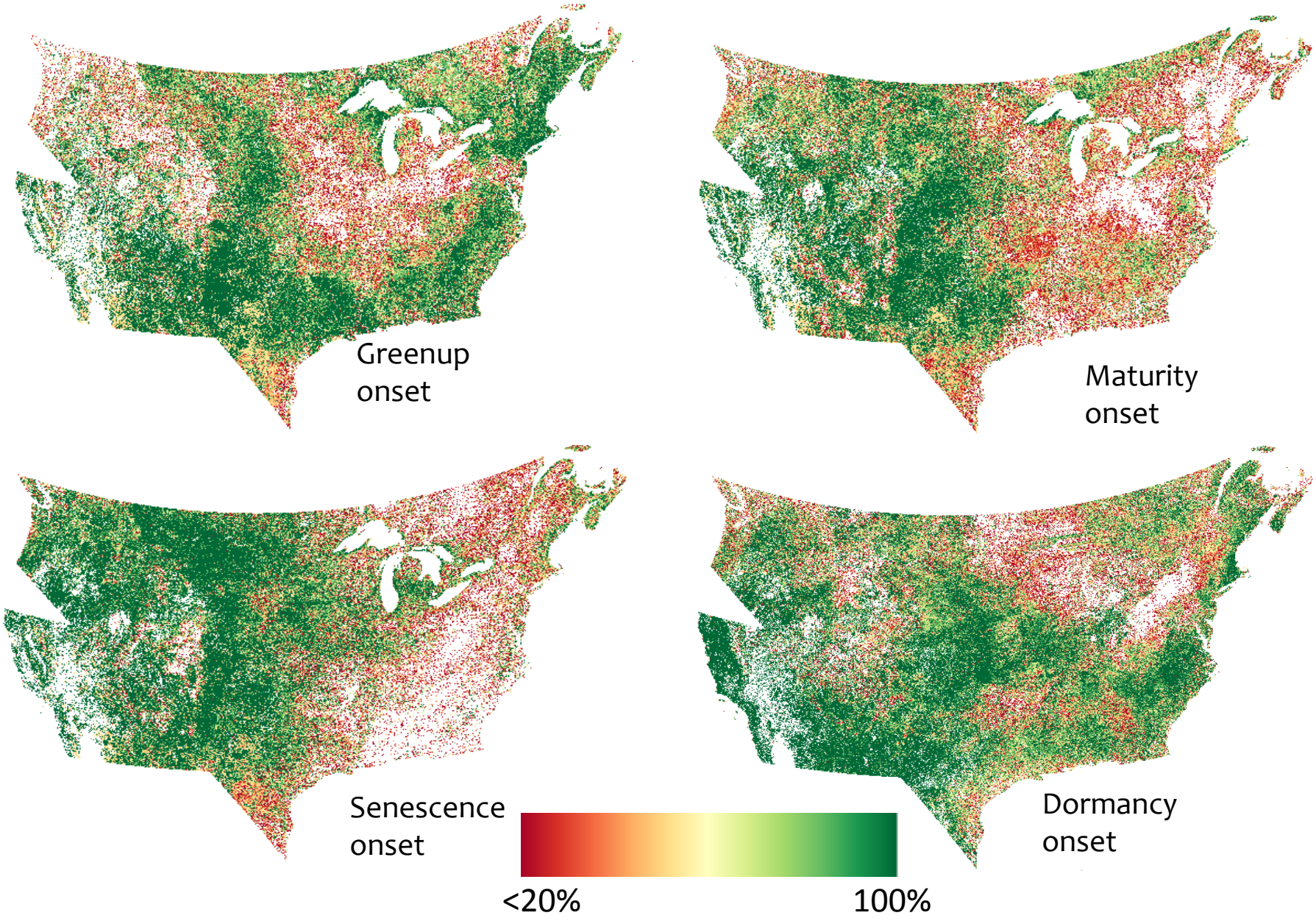




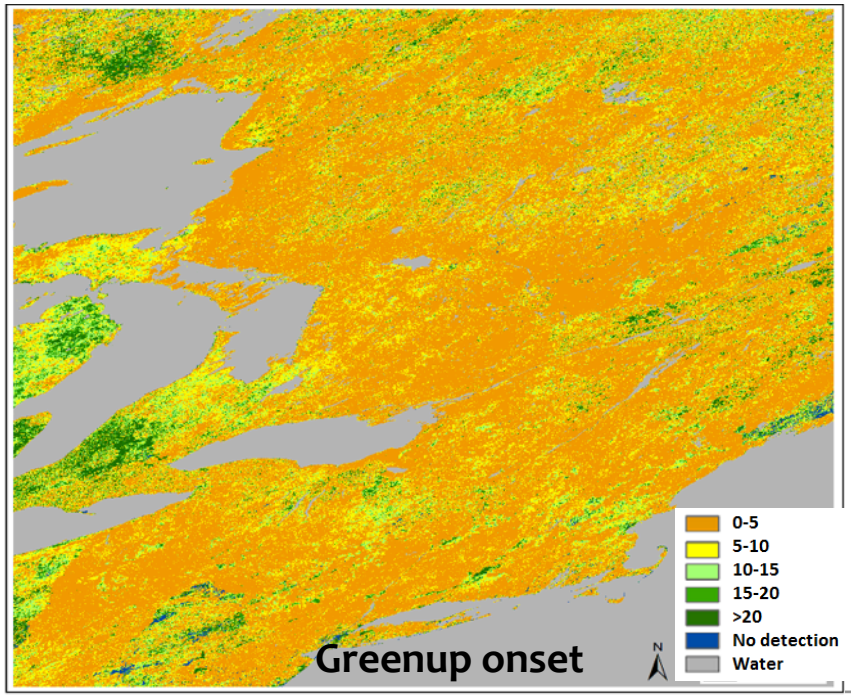
EVI2 in DOY 166, 2014

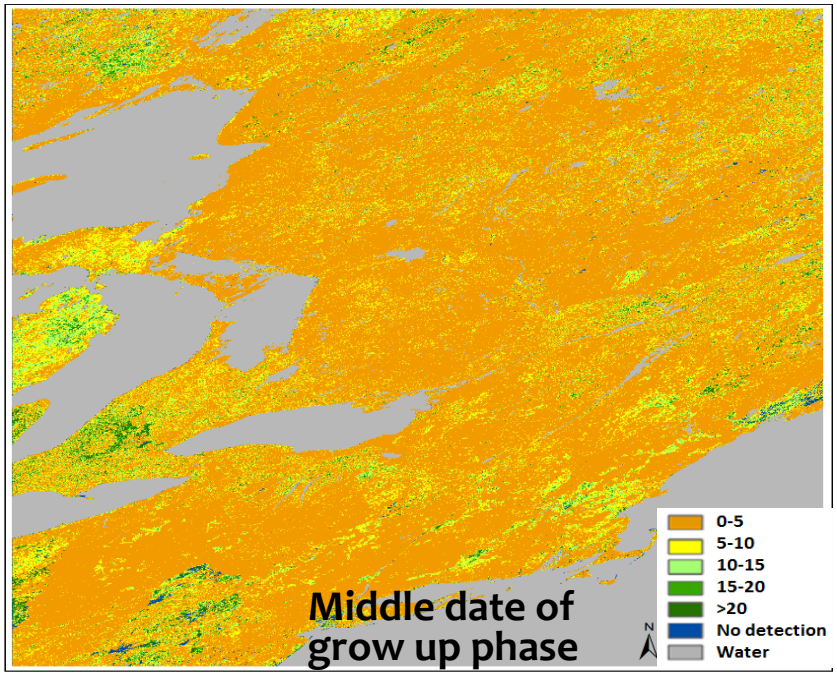
Quality of Time Series of VIIRS Data

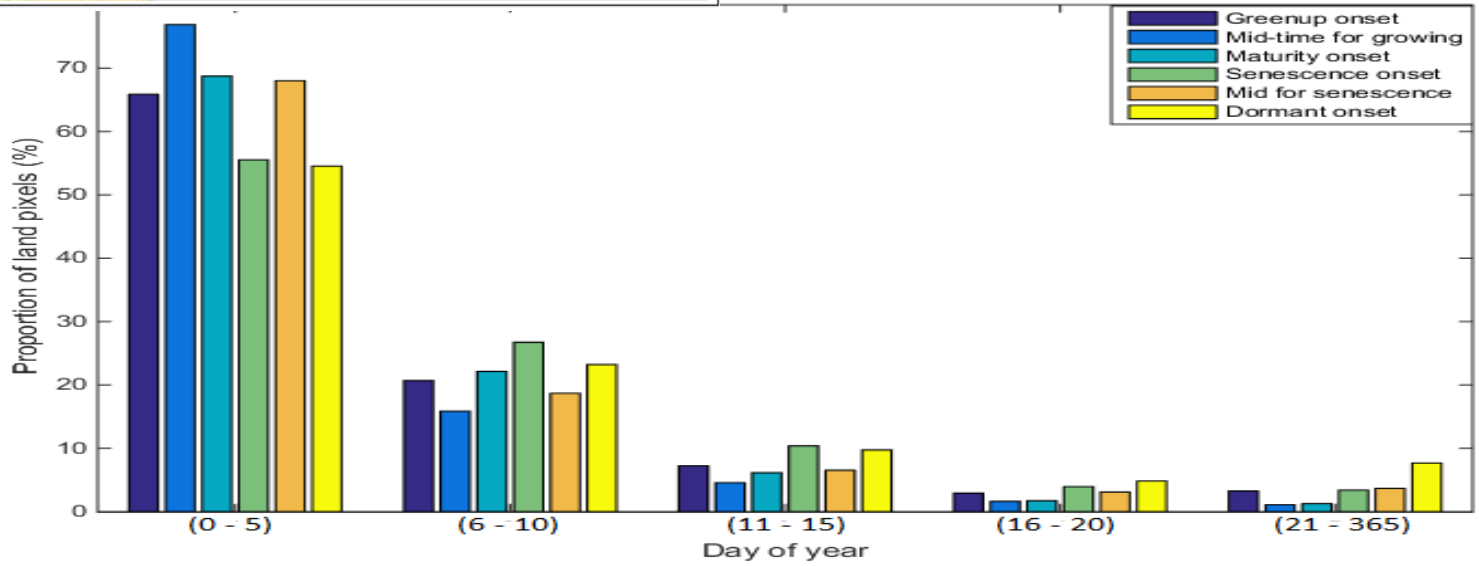
Proportion of Good Observations around Each Phenological Event (2013)



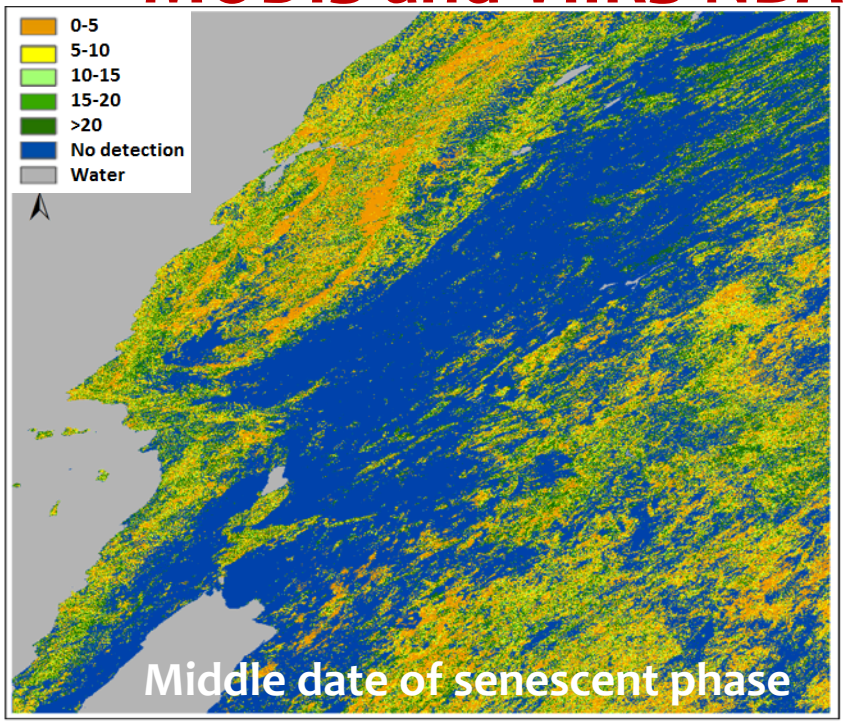
Comparison of Phenological Dates between MODIS and VIIRS NBAR Detections in Eastern US

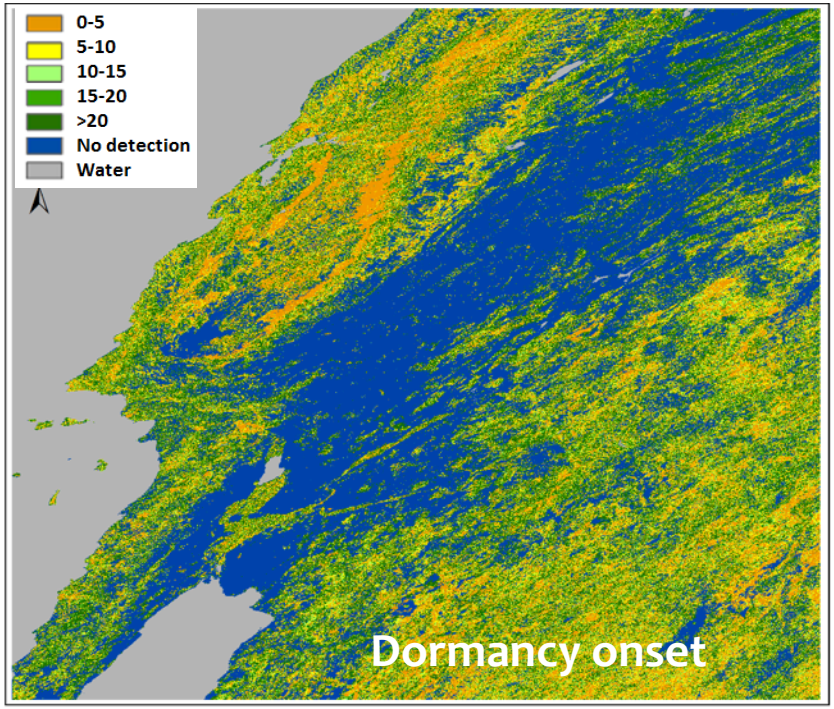


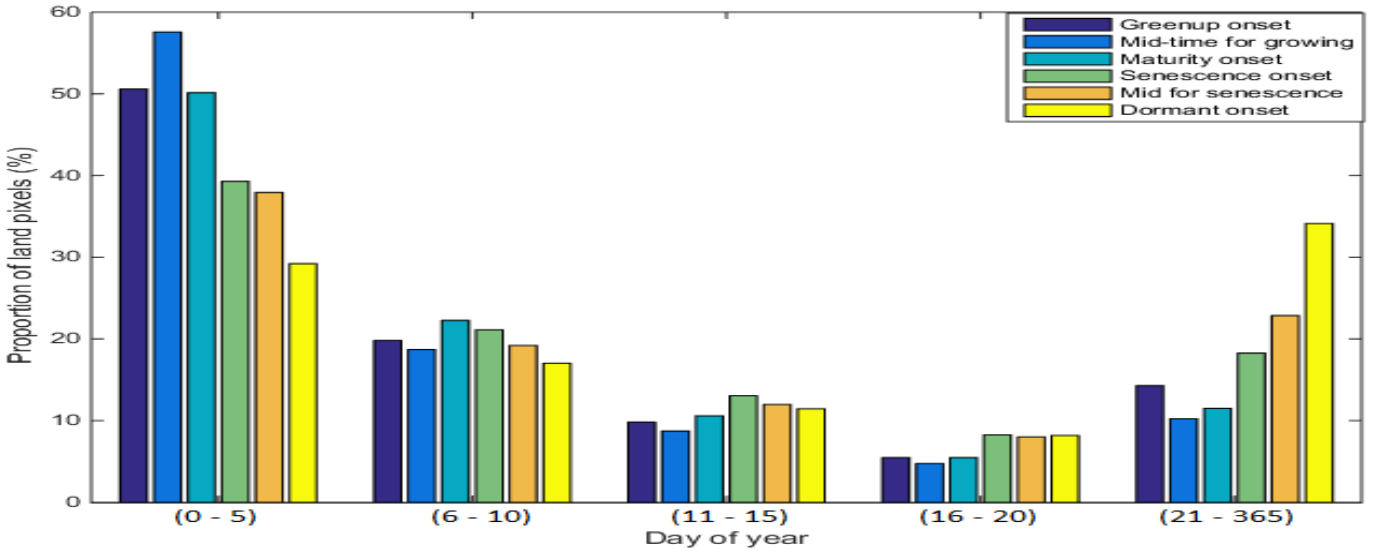




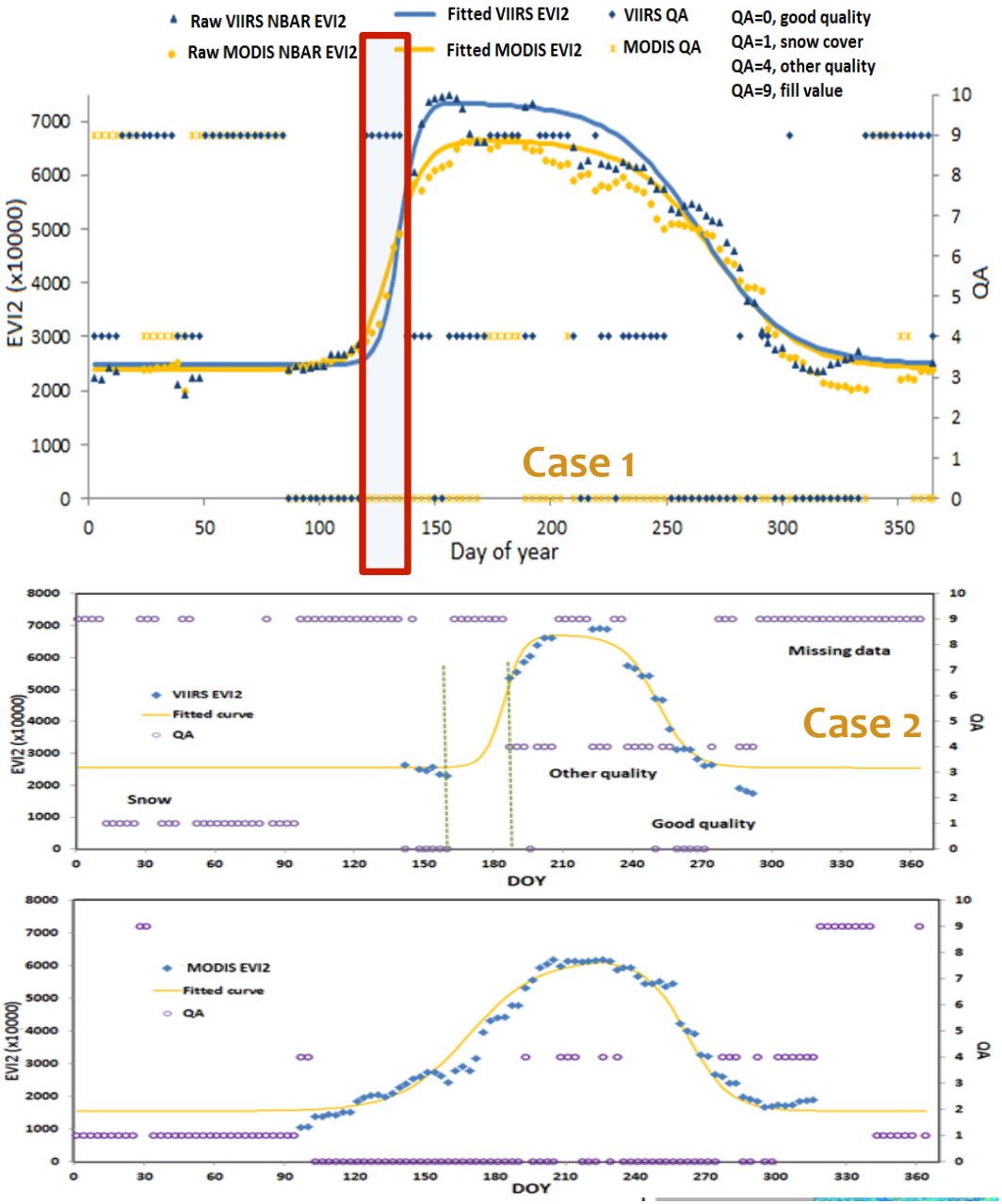
Comparison of Phenological Dates between MODIS and VIIRS NBAR Detections in western US

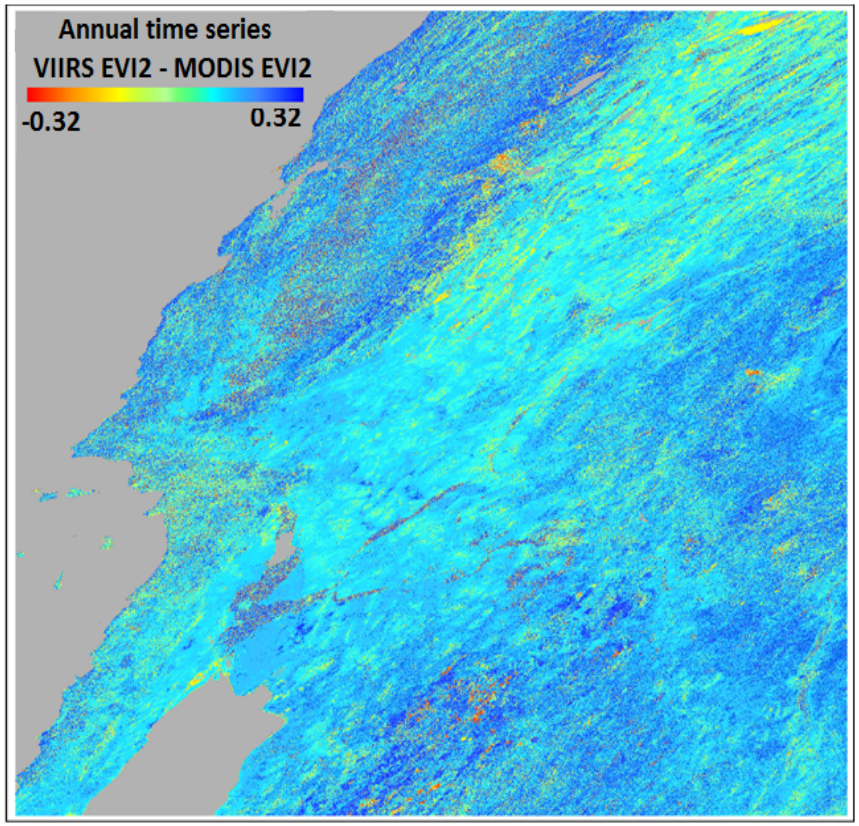




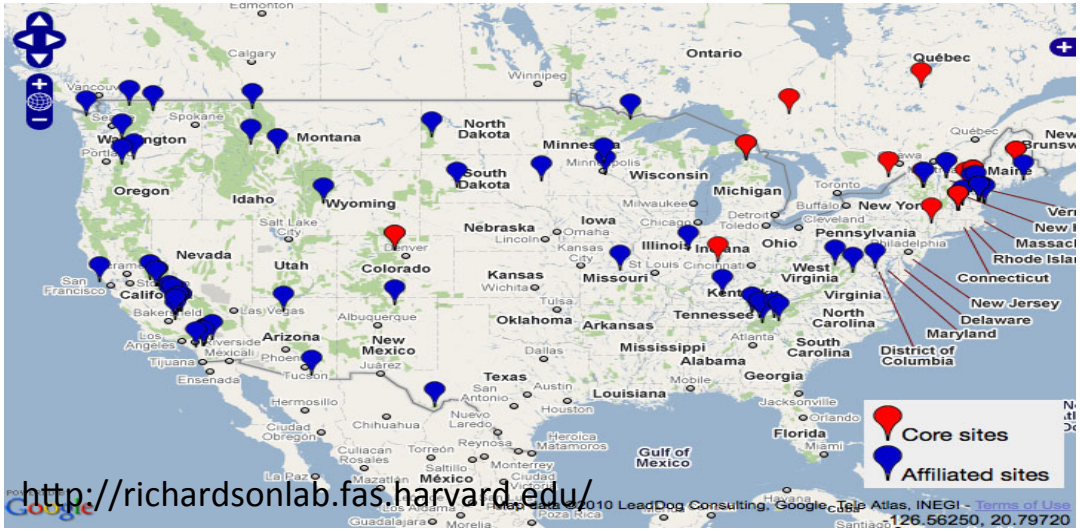


Difference of Temporal EVI2 trajectory between VIIRS NBAR and MODIS NBAR Data





Validation of VIIRS Phenology Using Phenocam Data

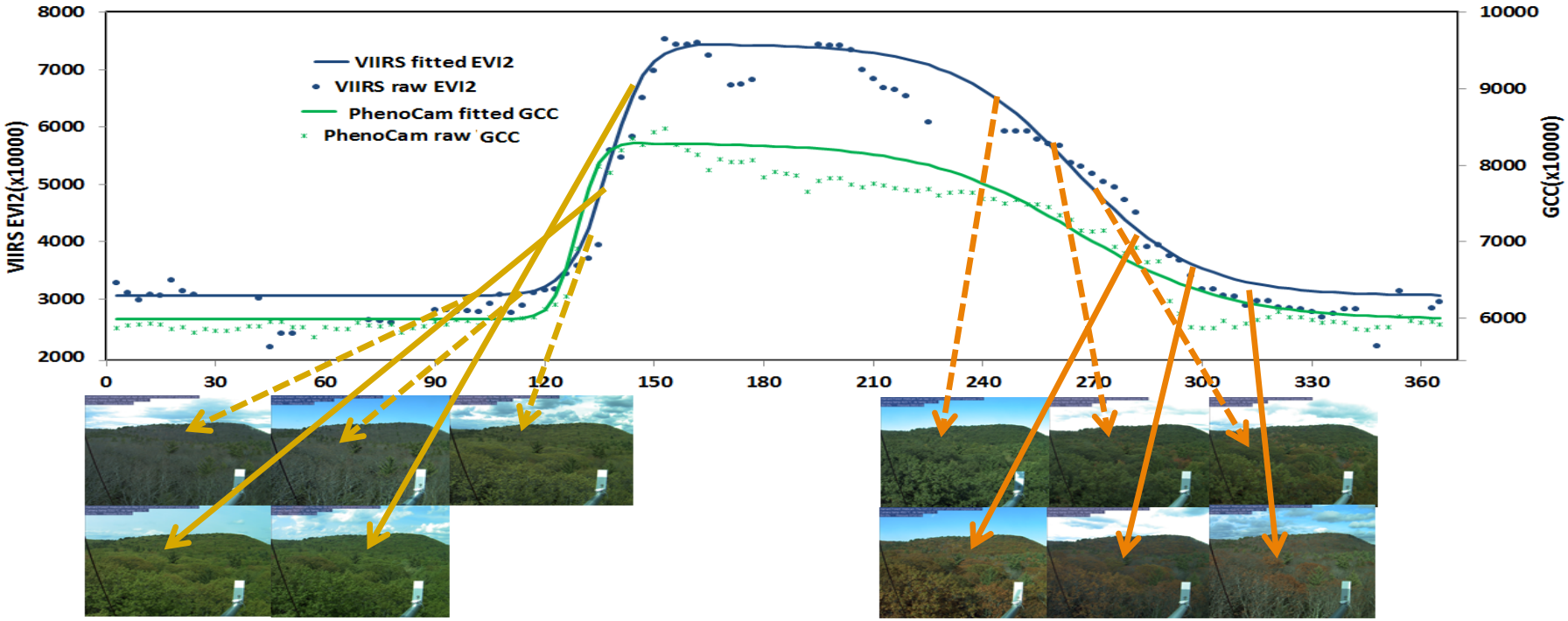


Green chromatic coordinate (GCC):

$$GCC = \frac{G}{R+G+B}$$

Vegetation contrast index (VCI) :

$$VCI = \frac{G}{R+B}$$

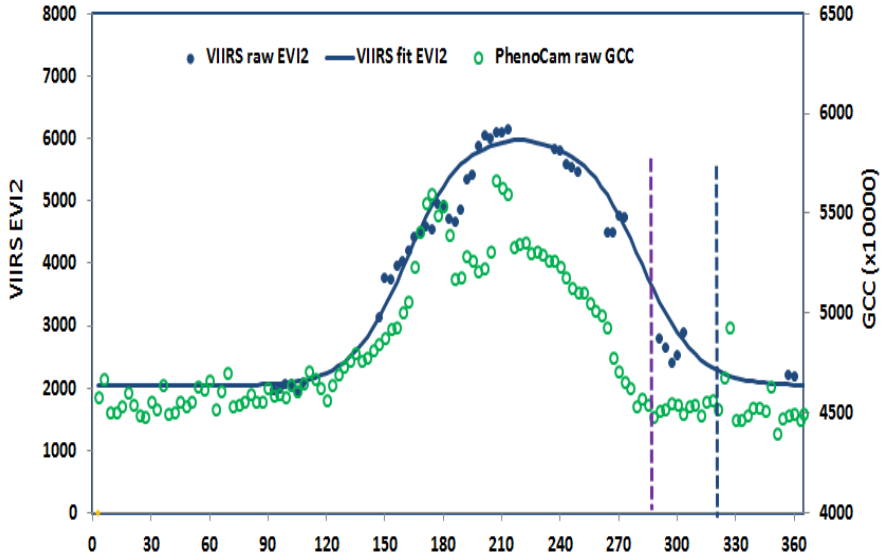


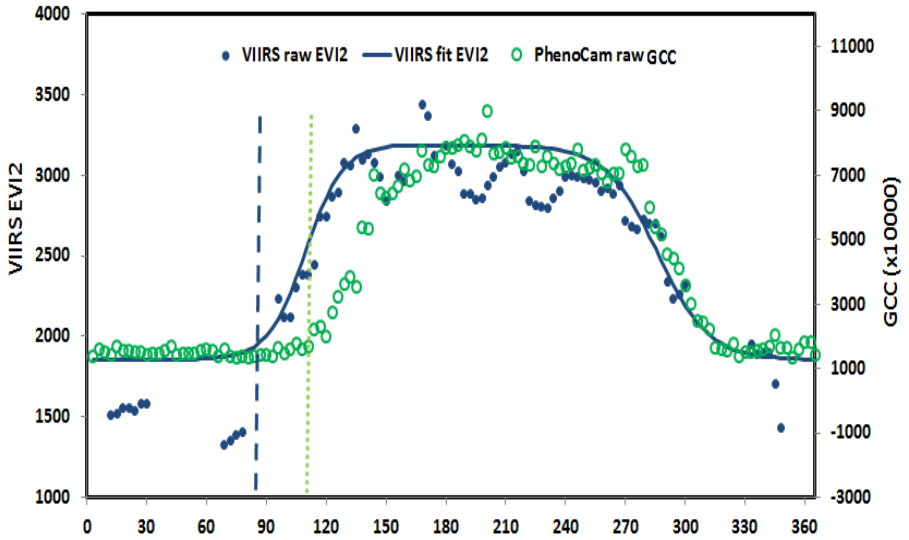
Comparison of phenology transition dates between PhenoCam and VIIRS observations

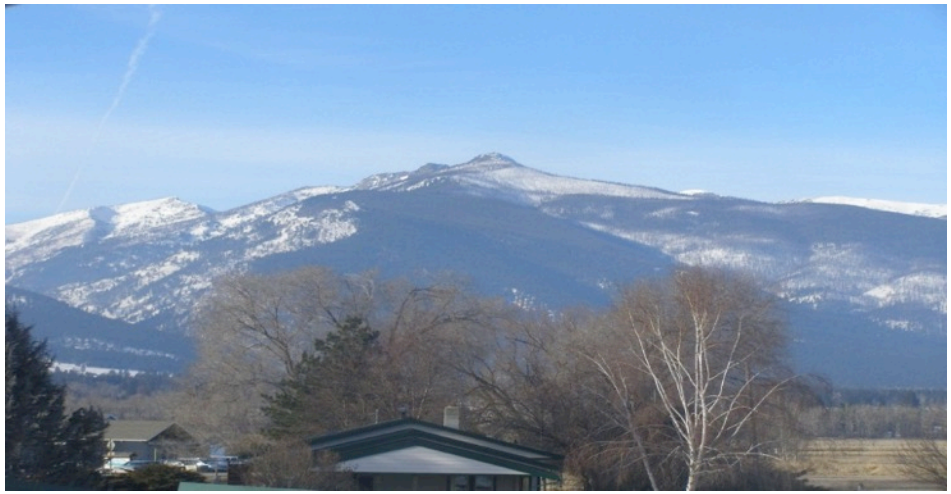
		Greenup onset	Mid-greenup	Maturity onset	Senescent onset	Mid-senescence	Dormant onset
2013 (100 sites)	AAD	6.5 ± 6.2	9.4 ± 6.3	11.4 ± 7.9	14.9 ±11.4	11.8±10.9	11.2±8.6
	Bias	-1	-2	-3	0	-3	-2
	RMSD	9.00	10.05	12.20	17.41	12.35	11.40
	R^2	0.87	0.85	0.79	0.75	0.68	0.54
2014 (95 sites)	AAD	7.3±5.8	7.1±5.1	10.7±6.6	16.7±10.9	12.8± 9.3	13.6±10.0
	Bias	0	-2	-5	-3	-4	-3
	RMSD	9.15	8.12	10.27	19.28	14.10	15.23
	R^2	0.88	0.88	0.83	0.74	0.87	0.78

AAD- Average absolute difference
RMSD-Root mean square difference

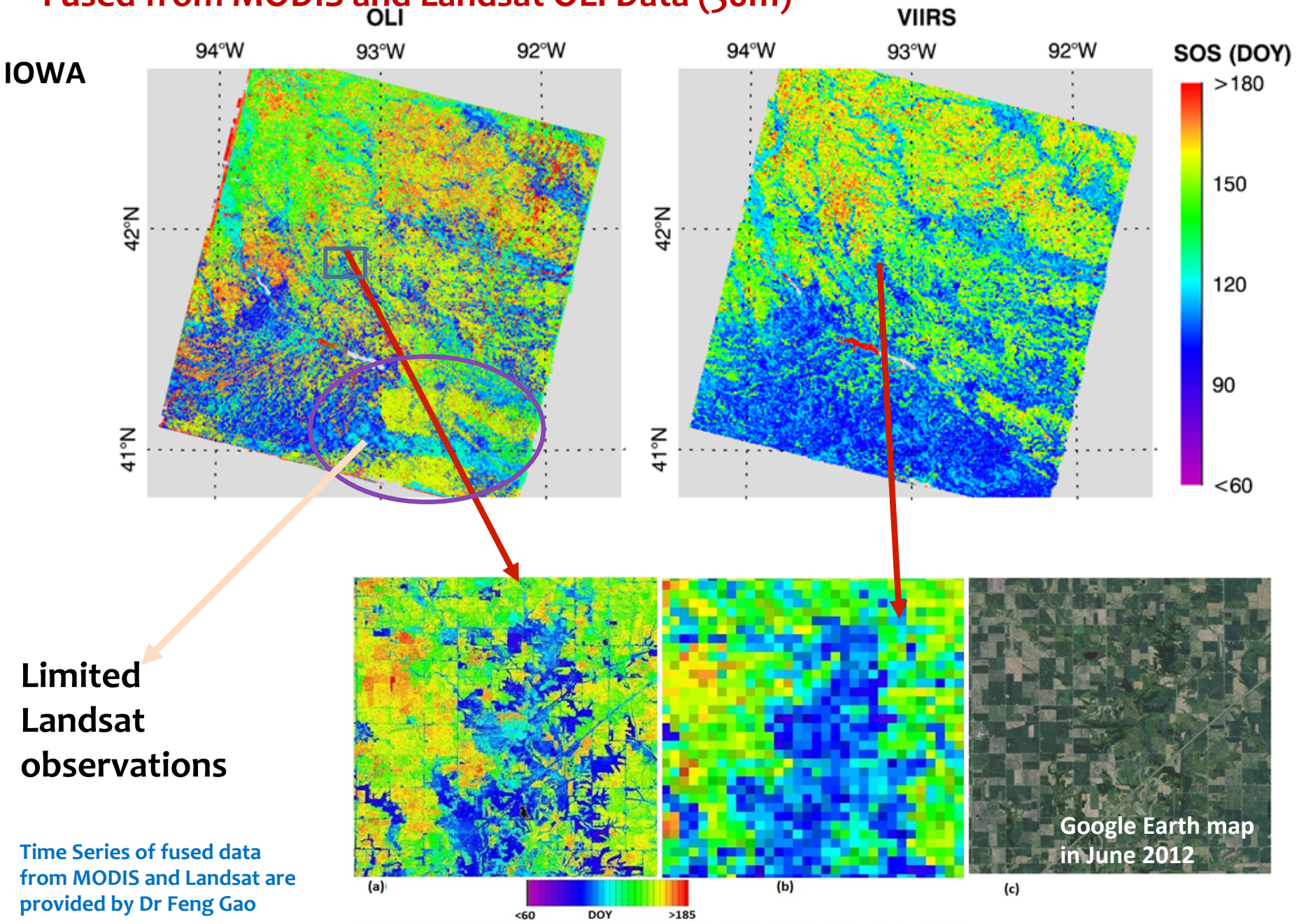
Difference Between Temporal VIIRS EVI2 and PhenoCam Data in Heterogeneous Sites







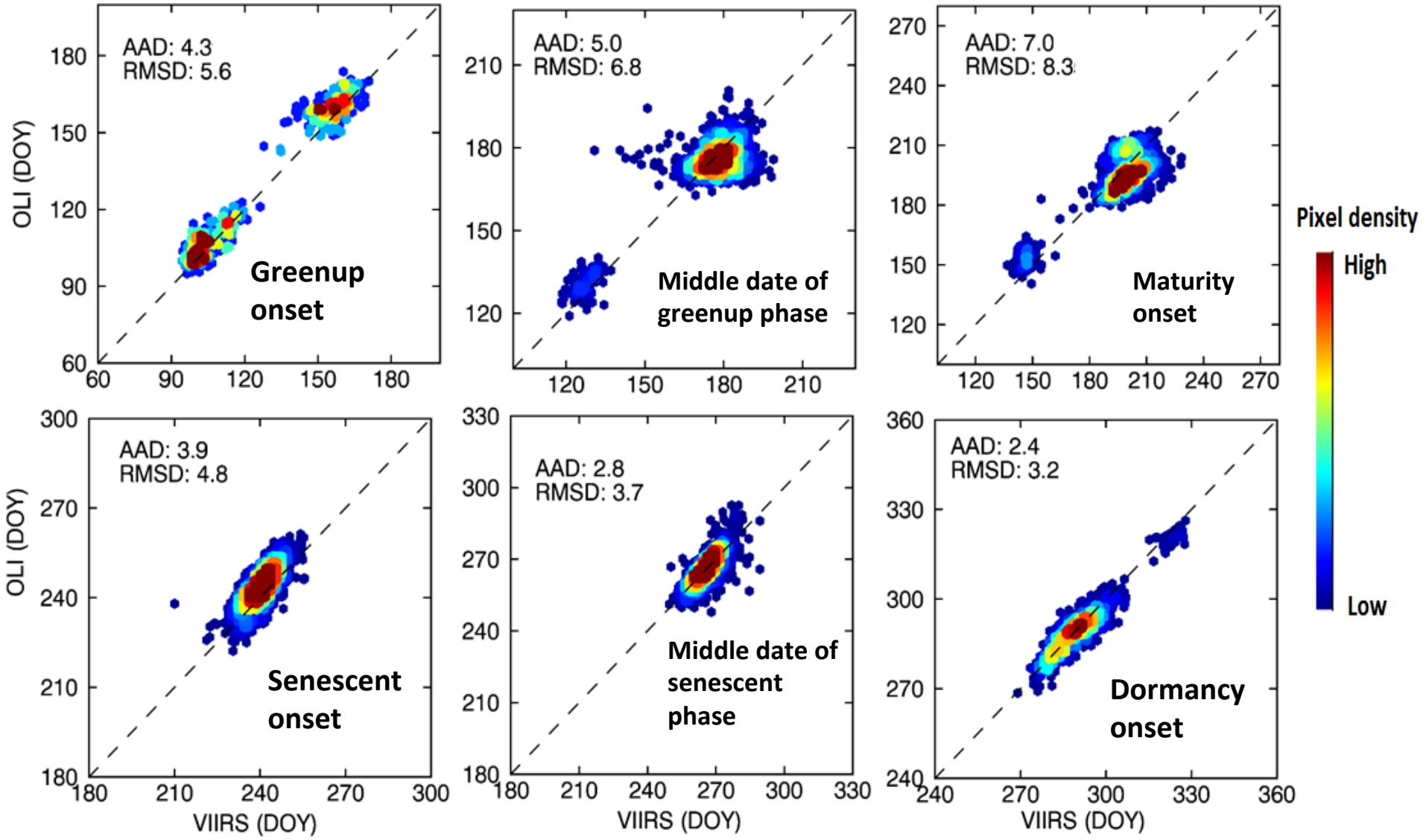
Validation of VIIRS Phenology Detections (500) Using Time Series Fused from MODIS and Landsat OLI Data (30m)



Time Series of fused data from MODIS and Landsat are provided by Dr Feng Gao

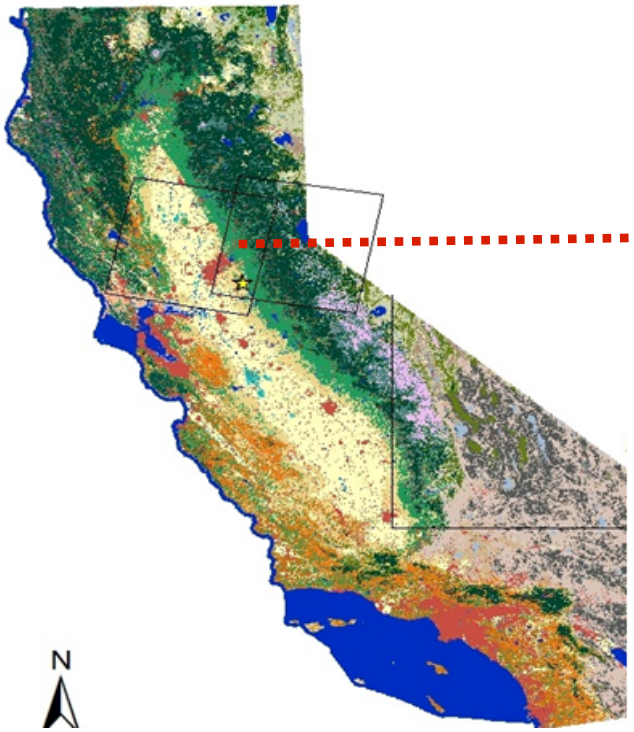
VIIRS Phenology (500m) vs Fused-Landsat Phenology (30m)

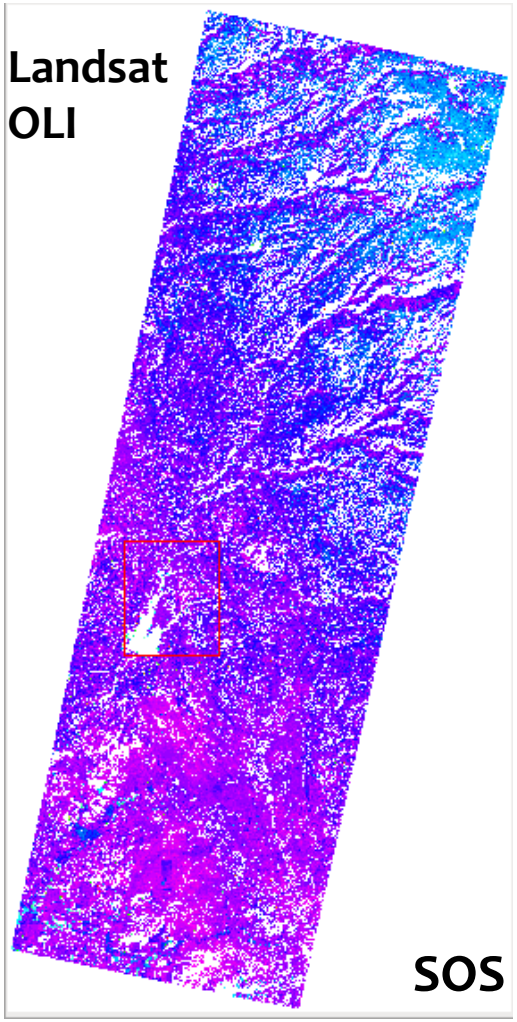
in 20% of the most homogeneous pixels (2013)

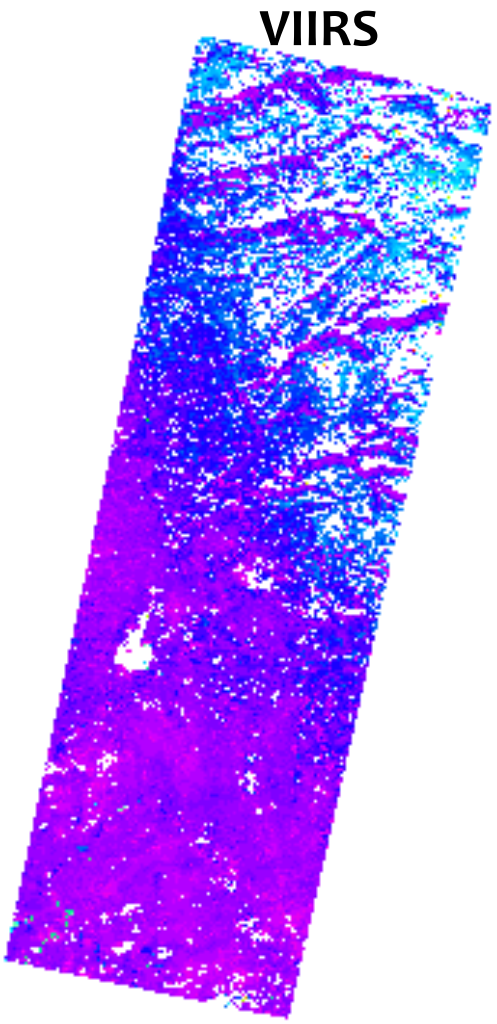


AAD = average absolute difference (day)
RMSD = root mean squared difference (day)

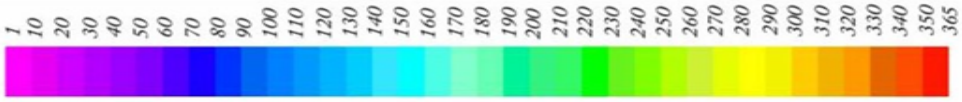
Validation of VIIRS Phenology Using Landsat Data in the Overlap Zone



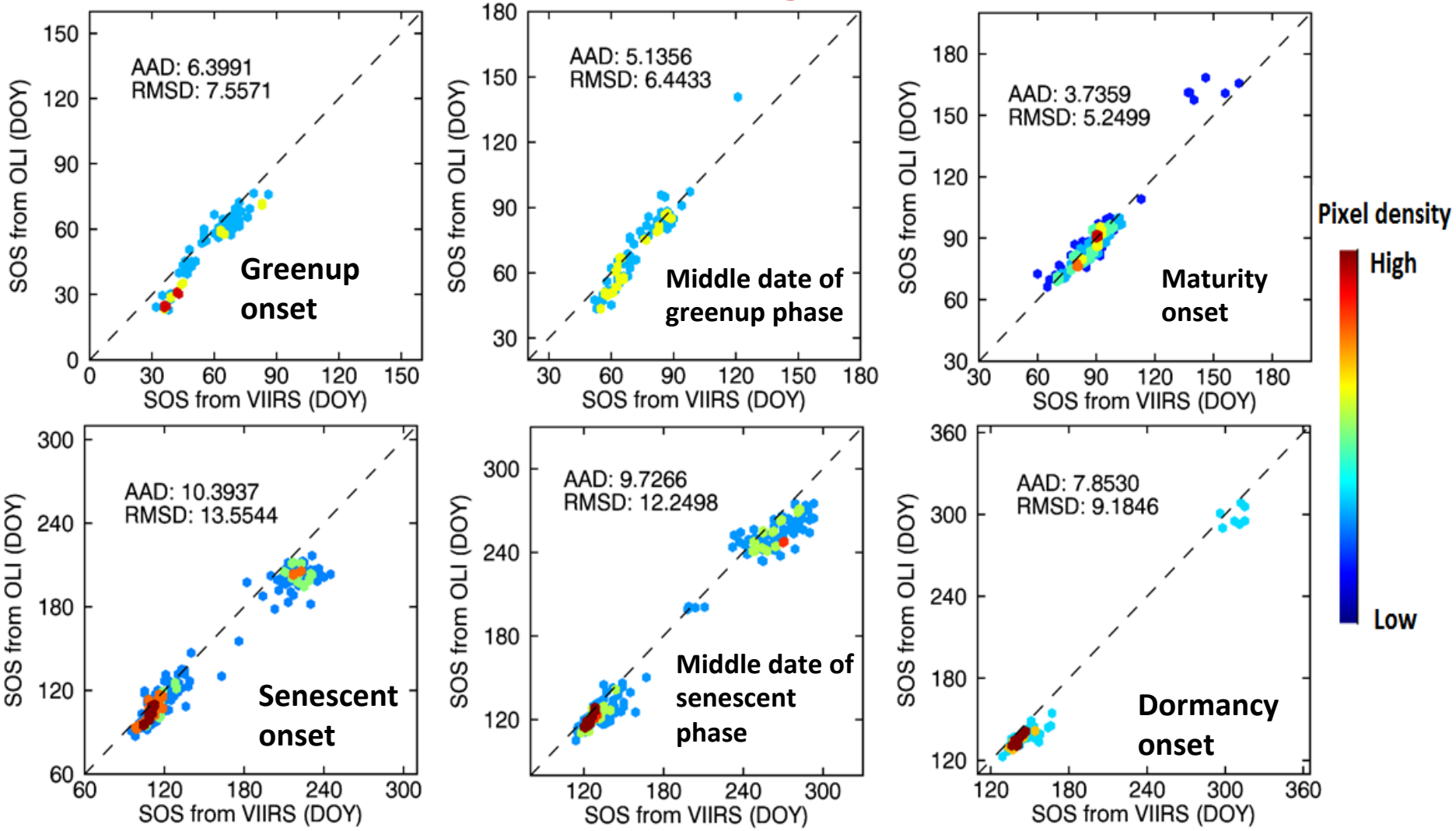




SOS in 2014



VIIRS Phenology (500m) vs Landsat SOS (30m) in 20% of the most homogeneous pixels (2014)

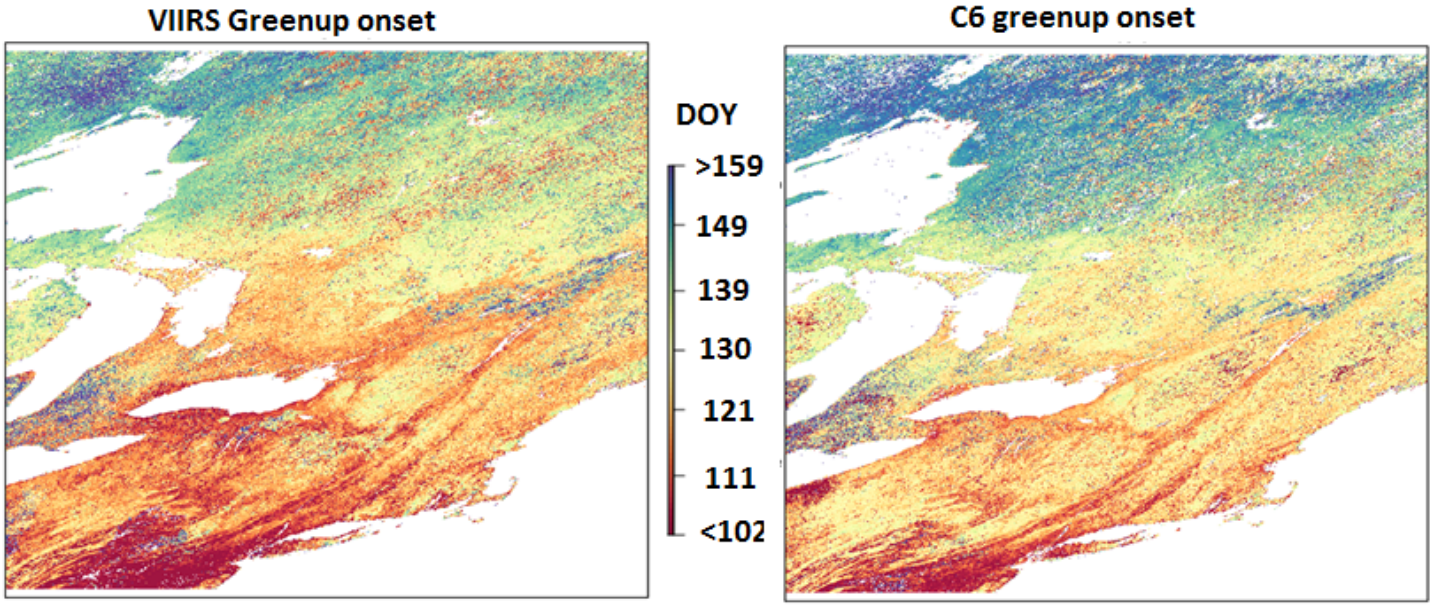


AAD = average absolute difference (day)
RMSD = root mean squared difference (day)

Comparison Between MODIS Collection 6 and VIIRS Phenology

C6 – 20% threshold in spline

VIIRS – Inflection points in hybrid piecewise logical models



Phenometric	H12V04 Mean Difference
Greenup onset	C6 is 4.2 days later
Middle date in greenup phase	C6 is 1.7 days later
Middle date in senescence phase	C6 is 4.7 days earlier
Dormancy onset	C6 is 7.4 days earlier

Conclusions

- VIIRS NABR Time Series has fewer good quality observations than MODIS NBAR (Terra+Aqua). Artifacts in VIIRS data may exist in some areas.
- VIIRS phenology is comparable with MODIS phenology, if the same algorithm is used.
- VIIRS phenology is similar to the results calculated from PhenoCam data, particularly during greenup phases.
- VIIRS and Landsat phenology detections are identical in relatively homogeneous regions. However, the difference can be large in heterogeneous regions.
- VIIRS phenology is generally comparable with MODIS Collection 6 detections.

Metrics of Land Surface Phenology

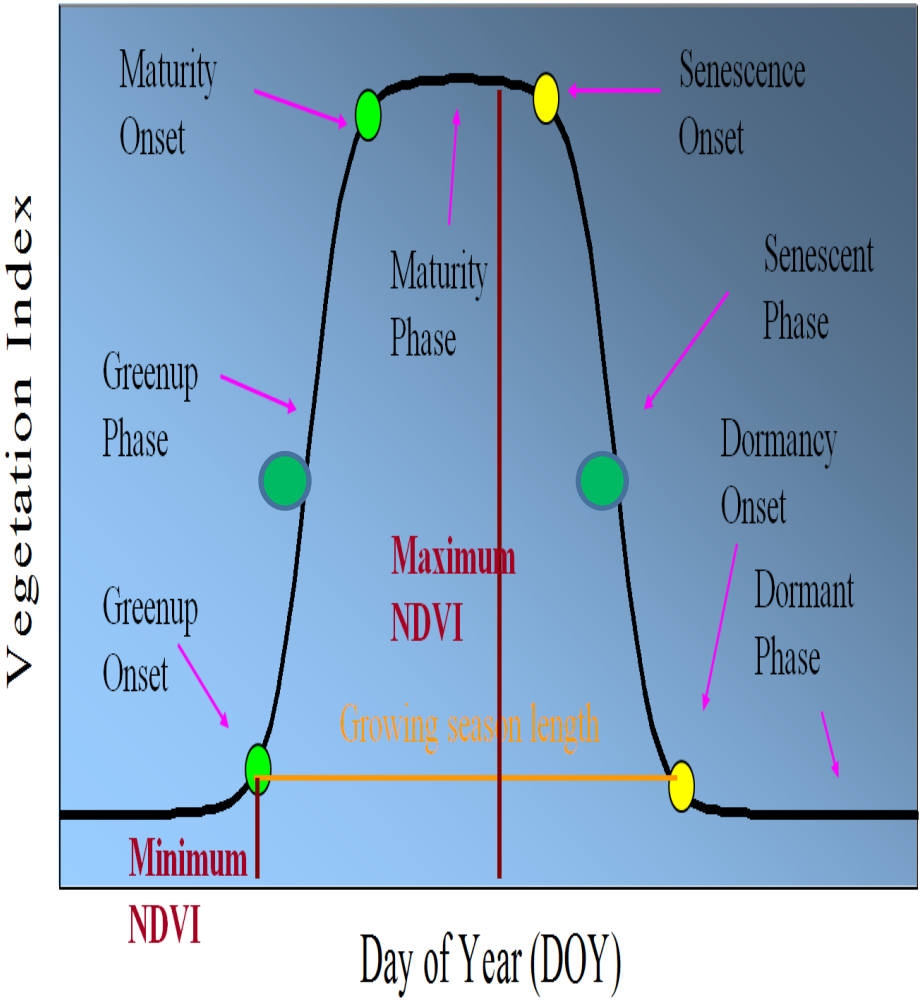
Timing:

1. Onset of greenness increase
2. Onset of greenness maximum
3. Onset of greenness decrease
4. Onset of greenness minimum
5. Middle date of grow up phase
6. Middle date of senescent phase

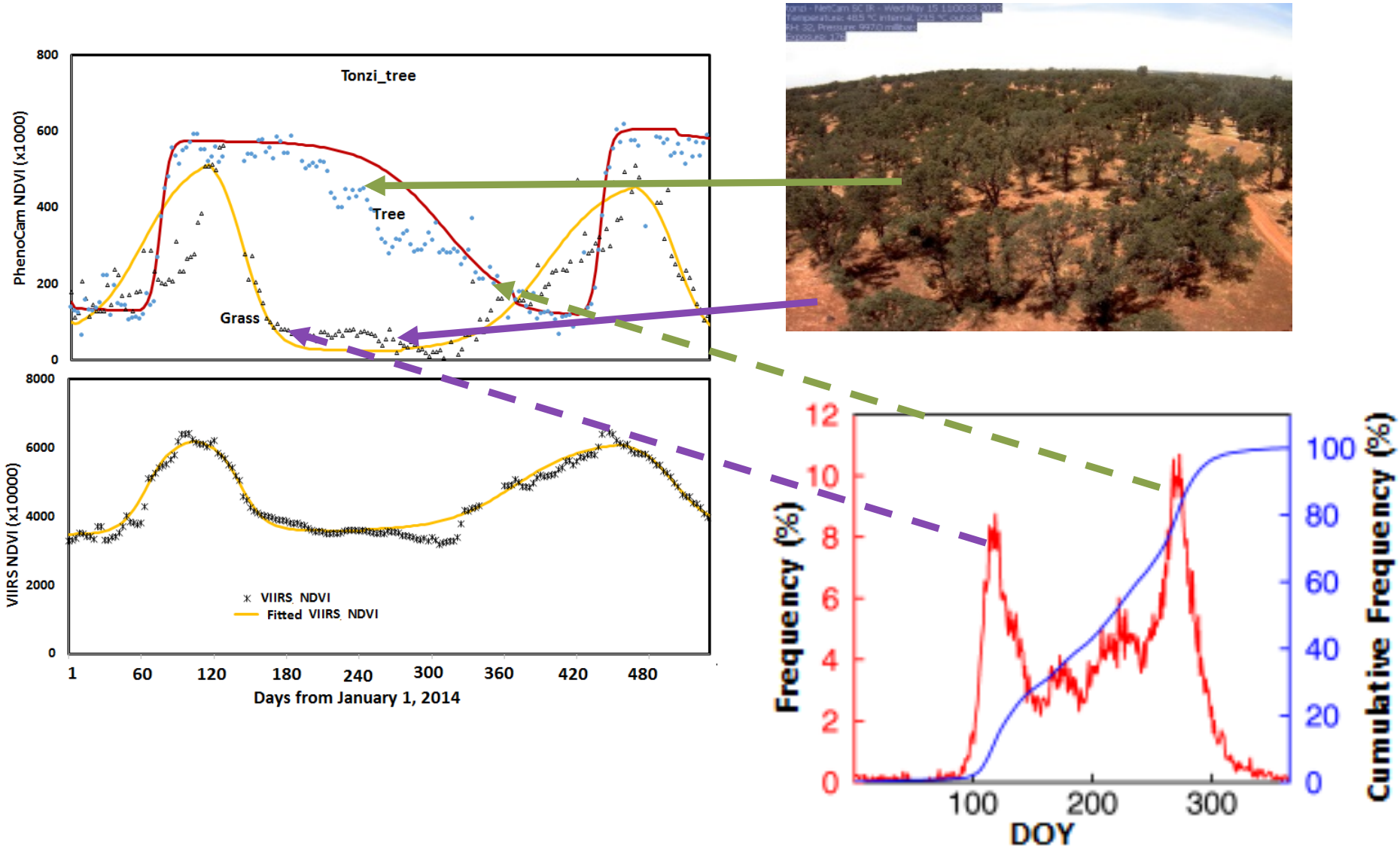
7. Onset of fall foliage low coloration
8. Onset of fall foliage moderate coloration
9. Onset of fall foliage near peak coloration
10. Onset of fall foliage peak coloration
11. Onset of fall foliage post peak coloration

Magnitudes

12. Growing season VI minimum
13. Growing season VI maximum
14. Summation of VI for growing season length
15. Rate of change in greenness increase
16. Rate of change in greenness decrease



Challenge of the Validation of VIIRS Phenology in Savannas



Frequency of Landsat EOS within a VIIRS pixel